FOUNTAIN PAINT POT NATURE TRAIL

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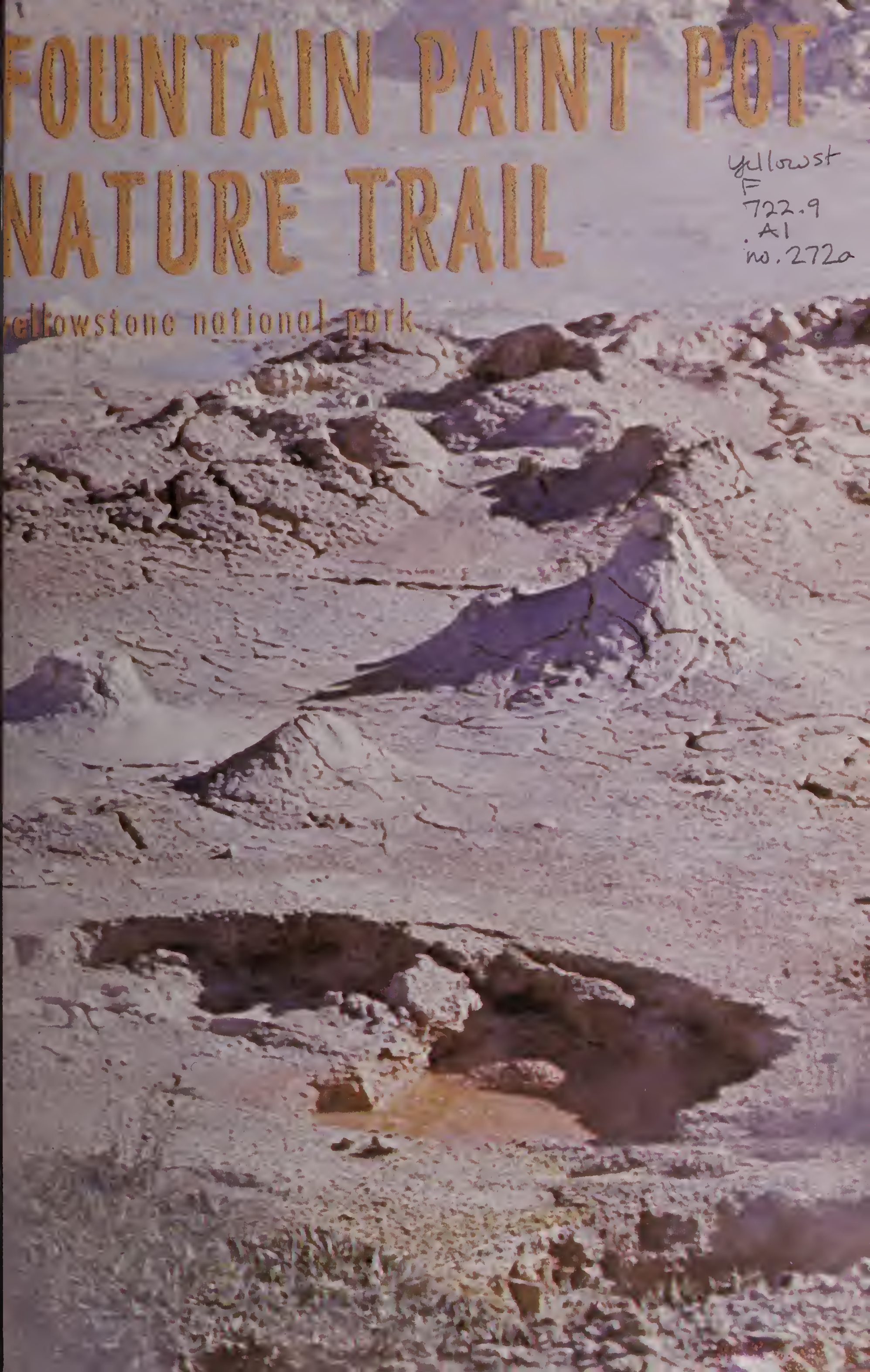

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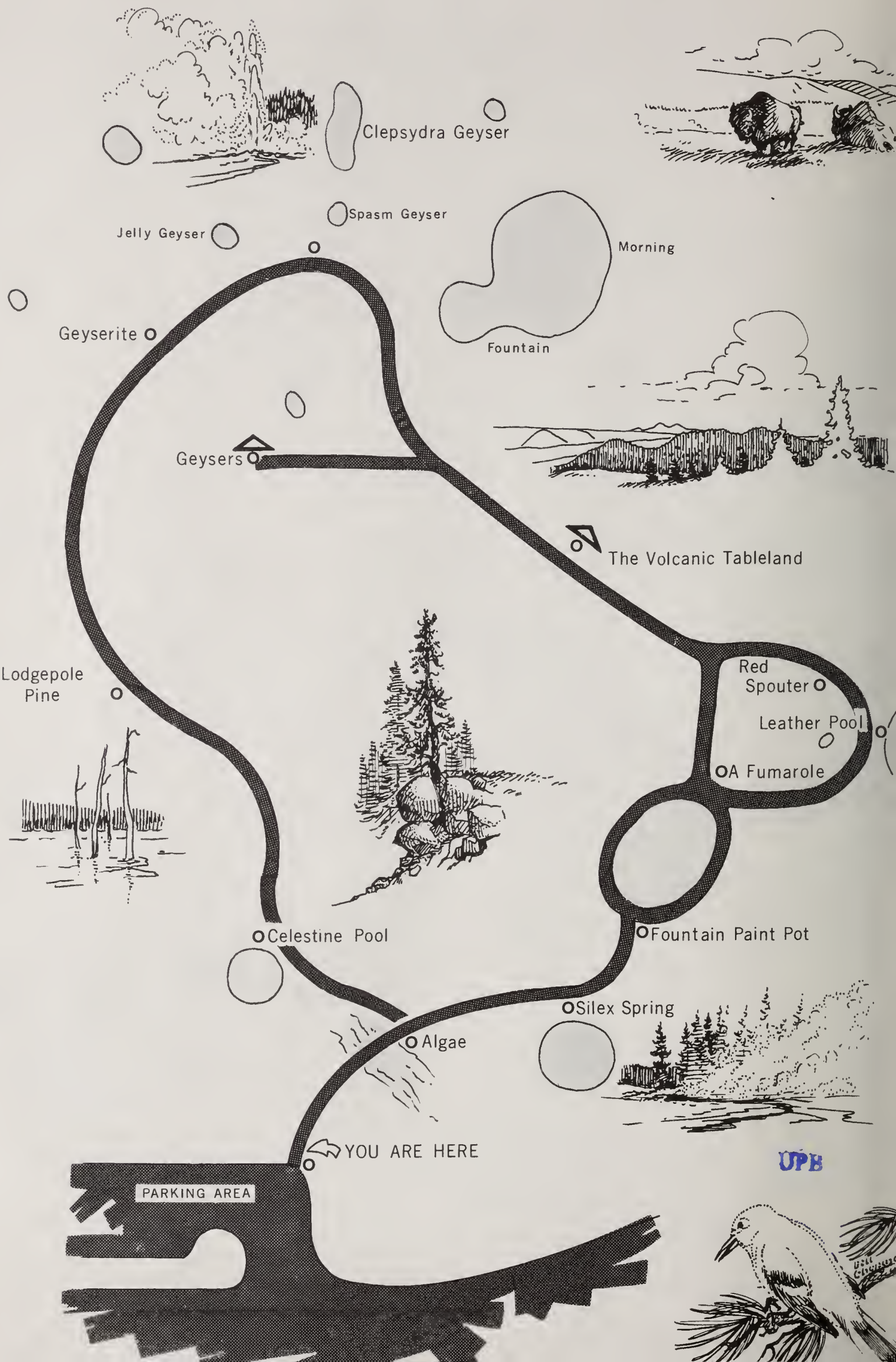

UPB

INTRODUCTION

Chances are you came to Yellowstone to see a geyser and maybe some of the big wild animals. If it is geysers you want to see, take this trail. From one point you can watch half a dozen geysers playing at the same time. Carry this booklet with you. It will help you understand the geysers better by explaining a few things along the way such as hot springs, paint pots and steam vents. The trail is a half-mile long.

There is a wild yet delicate scene ahead. The boardwalk will guide you by the safest route. Please stay on it and do nothing that might harm you or one of the rare features.

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ALGAE

The ribbons of color that stream from hot springs are usually formed by a plant called algae. It is common in ponds and streams the world 'round.

Carefully touch the water above the green algae and then touch the water above the orange. Notice the difference in temperature? Certain species of algae are predominate at different temperatures. Because these have different colors, they serve as temperature indicators.

At this stop you are safe in feeling the water. Do not touch hot spring waters elsewhere. You can be scalded!

Hot spring algae are a wonder of life at high temperatures. Some can withstand temperatures up to 163° F. These are the yellowish forms. As a rule the darker colored algae live at low temperatures and the light colored algae live at high temperatures. Certain varieties are scientific curiosities, because they are extremely specific in their environment. They may be found around the world living only in hot spring water.

Not all of the natural colors about hot springs are algae. Some vivid colors are chemical deposits. Sulphur, iron oxide and a few other deposits can be readily seen at Norris Geyser Basin.

SILEX SPRING

What you will be seeing along the trail are expressions of Yellowstone's volcanism; hydrothermal features. To the scientist the features have great differences, but they can be grouped generally into:

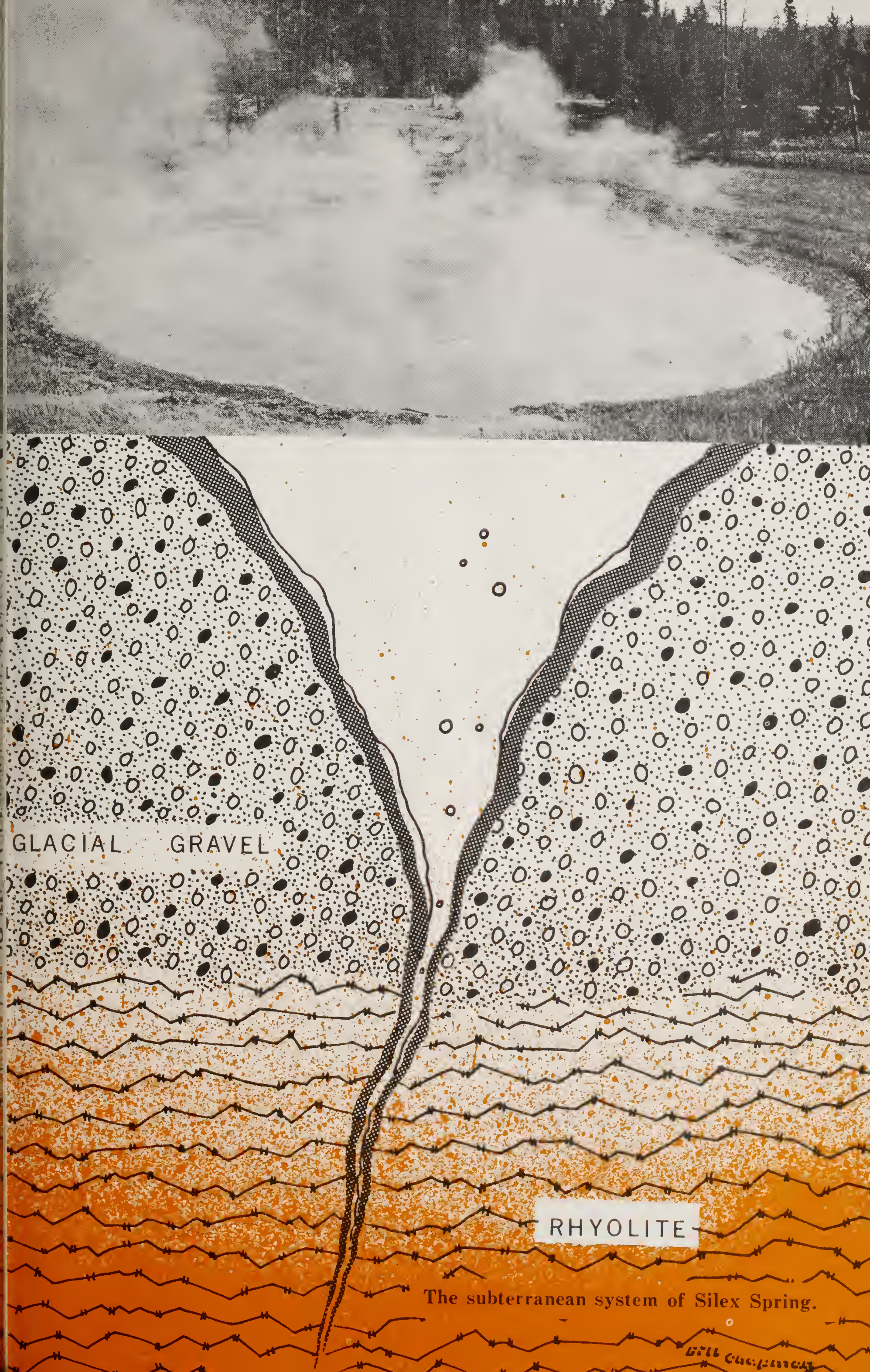
a) those that have a lot of water, or hot spring and geysers
b) those that have little water, or paint pots and mud volcanoes
c) those whose water is mostly steam, or fumaroles.

Silex Spring's water supply is so great that it overflows most of the time. The overflow, as you have seen, provides a home for algae and minute animals that find a tight yet favorable environment year 'round. But in the pool and at the head of the overflow, the water temperature is too great for any life. It is at the boiling point which is 199° F. at this elevation (7300 ft.).

Beneath you, rising volcanic gases exchange intense heat with water circulating in the ground. If the heated water can escape to the surface, a hot spring is formed. The diagram shows how a hot spring is thought to appear in cross section.

Glacial gravels fill the valley of the Firehole River. They are splendid carriers of water (aquifers). The water comes from rain and snow melt and is very soft.

When it meets the volcanic gases, the water picks up new chemicals. Some of the chemicals are elements scarce in nature, such as lithium, chlorine, fluorine and arsenic. They are found in concentra-



The subterranean system of Silex Spring.

tions that vastly exceed traces found in rock and the air. Yet the amount of these elements and minerals is so low in clear hot spring water that it would be pronounced potable and "soft" in most parts of the country. The chemistry of the water is a clue to the source of heat.

Let's go to the next stop and look at a paint pot.

FOUNTAIN PAINT POT

You have just climbed to an area of little surface water. The water supply varies seasonally. In early summer the paint pot may look like muddy water. By late summer the water content dwindles and the paint pot becomes viscous as mortar. You see steam bubbles bursting at the surface. These explosions occasionally lob mud up and over the guard rail. The most powerful springs of this type are in the Mud Volcano area six miles north of Fishing Bridge.

The mud is composed of clay and fine particles of silica. It is created in part by chemical decomposition of rock minerals and in part by mechanical pulverization as hard particles grind against one another. Springs such as Silex have these particles suspended in the water, but the particles are continually flushed out in the overflow. The clay-like materials are trapped in a paint pot and are ever growing in concentration.

Why should the water supply vary so greatly between Silex Spring and Fountain Paint Pot? While several conditions may affect the upper level of ground water (or water table), here it appears that the water table is near the surface of the ground at the spring but is deeper down at the Paint Pot. Water tables rise under hills but do not come so close to the surface as in low places. The water table is usually nearest the surface at the base of a hill and that is where springs frequently appear. When there is a bountiful water supply, the water table rises high enough to noticeably dilute the paint pot.

The local rock is largely rhyolite which is abundant in silica and feldspar. Acids in the steam and water break down the feldspar into hydrous aluminum silicates, or, as they are better known, clays. Kaolinite is the prevalent clay mineral here. The clay in pure form would be white, but depending on the degree of contamination by iron oxide will vary through shades of red.

A steam bubble bursting in the Fountain Paint Pot.

A FUMAROLE

Down this hole is a direct line to the volcanic heat; the steam and gases are escaping from the heat source which is thought to be liquid or at least semi-liquid rock (perhaps magma). One of the volcanic gases is hydrogen sulphide. Near the surface it combines with oxygen to form sulphuric acid which leaches the underlying rock and weakens it. As the decay continues, the ground collapses and the crater is enlarged. In time, this crater may join the paint pot cauldron. The steam vents at this end of the paint pots broke out through a flower strewn grassy cover following the 1959 Hebgen Lake Earthquake. Very little ground water enters the vent and what does is instantaneously converted to steam. The steam temperature is 202° F. which means it is superheated.

Skeptics will wonder how it is known that this is magmatic steam. In truth we do not know conclusively but several facts strongly indicate that it is magmatic steam. The steam is hotter than steam given off by pure water at atmospheric pressure. It can hardly be steam from ground water heated to the boiling point by hot rock. Further, it escapes at a velocity higher than would be expected from steam that is in equilibrium with pure water. The theory that best accounts for this evidence is that the superheated steam is liberated from molten rock. In support of this, remember, too, the relatively high concentration of rare elements found in Yellowstone's hydrothermal features.

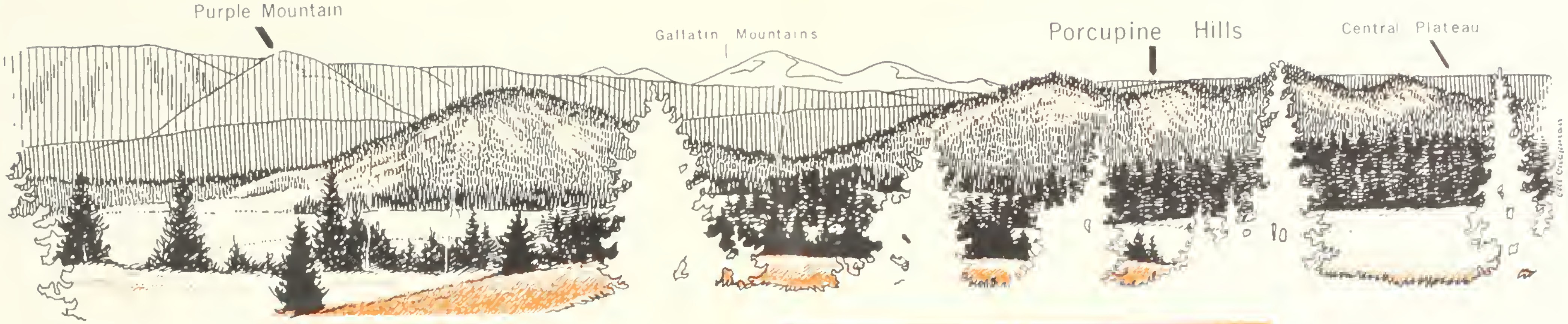
The great problems remaining unsolved are: What is the structure of the heat source? How is it shaped? How far down is it? Is it primary magma or a still cooling buried pile of lava flows?

LEATHER POOL

Hot springs are in a constant state of change; the change being almost imperceptible except by comparison of records over decades. Earth movements cause abrupt changes. Before the Hebgen Earthquake, this pool was at low temperature. Leather-like brown algae lined the bowl. Following the quake, the water temperature increased from 143° F. to boiling and killed the algae. The temperature still remains above the critical point for life.

Geologically speaking, hot springs are very fragile. Glacial gravel is unstable material and in this basin the gravel is honeycombed by the sinuous roots of springs. The basin is particularly vulnerable to earthquakes. The jarring energy of a quake can make gravel bounce

THE VOLCANIC TABLELAND



atop solid rock as does a marble on a wood floor that is hit by a hammer. As the gravel particles vibrate, their positions are readjusted. Compaction usually results and water displaced from around rock particles is forced to the surface carrying muddy material that clouds surface pools. Fractures accompany compaction and water levels in some springs drop as their discharge is diverted. Others increase in temperature as steam and hot water are directly led to them through newly opened fissures.

In the days after the Hebgen Earthquake, all of the above changes were observed in various springs of the Firehole geyser basins. The epicenter of the quake was determined to be about 15 miles airline northwest of here.

RED SPOUTER

This spring originated with the Hebgen Earthquake. It, too, is an example of change—seasonal change. During the summer months, it is a fumarole, but from late fall to early summer it spouts brilliant red water.

Red Spouter's activities vary with the fluctuating water table. Note that it is situated on the hill higher than Leather Pool and lower than the paint pots and fumarole. As the water table seasonally rises and falls, Red Spouter passes through phases of being either a fumarole or a watery paint pot. It has never received enough water to become a pool.

THE VOLCANIC TABLELAND

Looking north you see a panorama of the major events in Yellowstone's geologic past. These events have inexorably led to the weird features of this basin.

The landscape before you had its beginning when the earth's crust was bent, fractured and heaved into high mountain ranges such as the Gallatin. Then followed a period of fire that started with volcanoes which showered the region with ash and rock fragments. But the bulk of the Yellowstone Plateau is rhyolite that welled from fissures as lava flowed or raced across the landscape in holocausts of incandescent clouds. Rhyolite engulfed all but the highest peaks and is seen here as the horizontal skyline of Purple Mountain and the Central Plateau. Yet the land was to be buried again, and this time by ice! In the Ice Age, mountain glaciers to the northeast coalesced and spread southwest over the plateau. Fumaroles and perhaps even hot spring pools and geysers followed each extrusion of rhyolite. At this spot the ice vied for occupancy with hot springs. Eventually the springs were smothered but not until they had melted so much ice that gravel was heaped on them. When the glacier retreated, the gravel ridge was left behind to form the Porcupine Hills. On cold days, one can see steam rising from the hills.

The events described occurred over a period of 70 million years. They are not finished. Mountain making continues and there is evidence that we are merely between periods of volcanism and glaciation. Whether active or subdued the products of these events are Yellowstone's most improbable wonders . . . geysers. At the next stop it is possible to see half a dozen geysers playing at the same time.

GEYSERS

Before you is the liveliest collection of geysers in the Park. Take a moment to spot the numerous locations where you see water leaping skyward. What is a geyser? A geyser is a hot spring that intermittently gushes forth water. This phenomena occurs at only a few places in the world and it is rare in those locations. Ten percent of the Yellowstone hot springs are geysers whereas in Iceland only one percent are geysers. The world's geysers are concentrated in Yellowstone and many of them play to great heights.

In comparison with a conventional hot spring, the "plumbing system" of a geyser is probably more intricate. The system has a delicate pressure/temperature balance that can be suddenly upset. A subterranean steam explosion is then triggered and water is driven upward. Yellowstone's geologic past has provided geyser essentials: 1. a high flow of volcanic heat and, 2. deep glacial gravel beds that carry an enormous volume of water and have the potential of developing complex underground chambers and connecting passageways.

The eruptive mechanism of a geyser is not really known. No one has ever seen the construction of a Yellowstone geyser and no extinct geyser, intact and cool, has been found that possibly could be explored. At Whakarewarewa, New Zealand such a feature was discovered. It is described as "a circular hole . . . . . . just large enough for a man to squeeze his body through. . . . . The mouth of the geyser apparently leads down a short tube into a vaulted cavern into the floor of which open small passages by which the steam or hot water must have entered. The walls of the tube and of the cavern are lined with smooth bossed masses of silica."

A typical geyser might be likened to a series of pressure cookers with relief valves connected to a main vent. In the diagram the side chambers are the pressure cookers. Cooler water in the vent pipe serves as a pressure valve. Water in the side chambers will remain liquid if hydrostatic pressure in the vent pipe is greater than steam pressure in the chambers. When the steam pressure increases enough to lift the load of cooler water in the vent pipe, some water overflows and the hydrostatic load is lightened. If the load is lightened to a criical point, the superheated chamber water flashes into steam and an eruption is on. The eruption ends when superheated water is exhausted. If liquid water is exhausted first, a steam phase follows until the superheated water is spent. Refilling of the chambers ends the steam phase. Refilling can be abrupt, sometimes slow. A conventional hot spring has no confines that trap steam and so it escapes freely in fumaroles and boiling springs.

Scientists speculate that a geyser's underground plumbing system is generally as shown here. The depth/temperature data are from an actual test hole drilled six miles from here.

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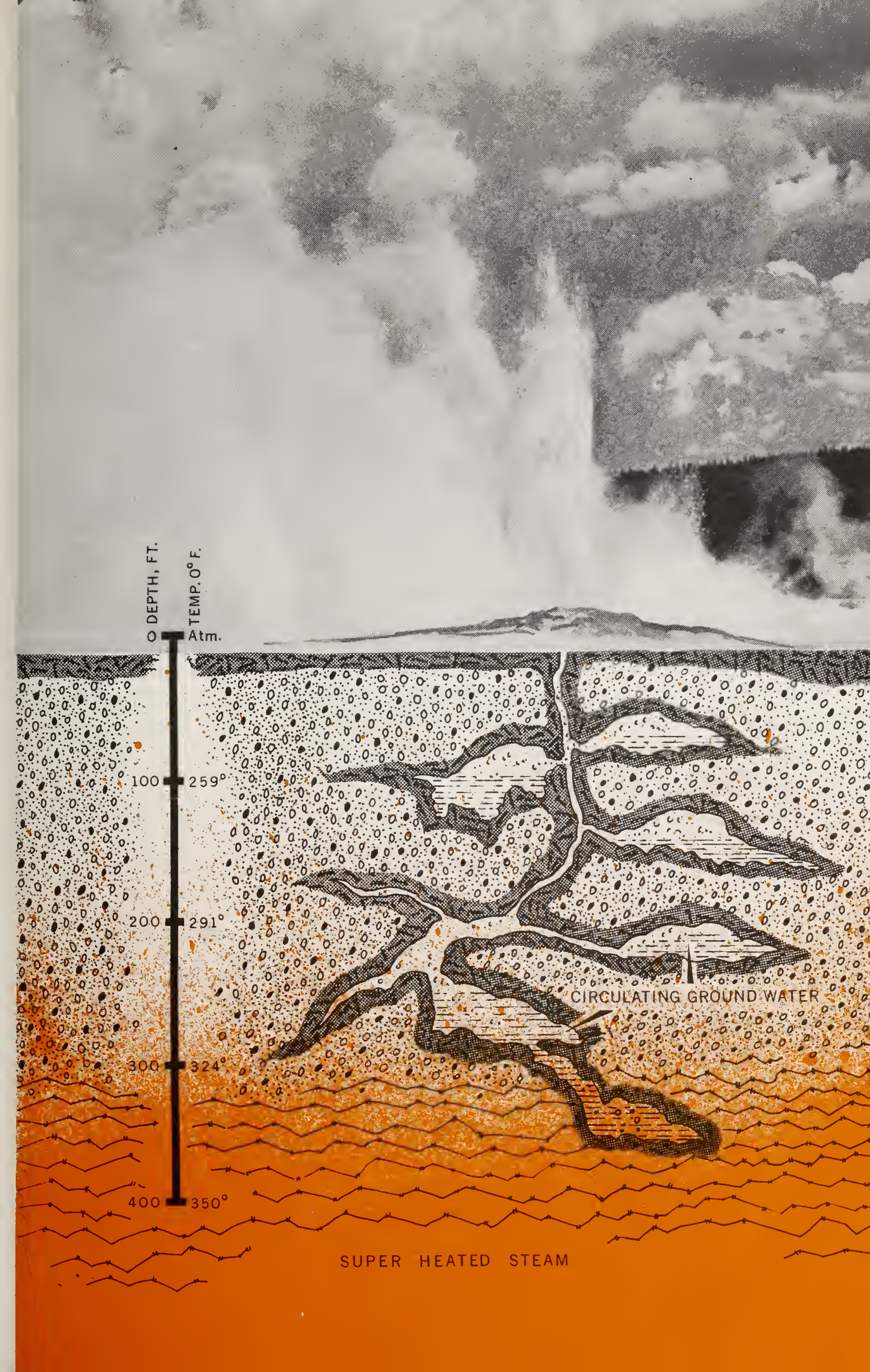

DEPTH, FT.
TEMP. 0° F.
0
Atm.
100
259°
200
291°
300
324°
400
350°
CIRCULATING GROUND WATER
SUPER HEATED STEAM

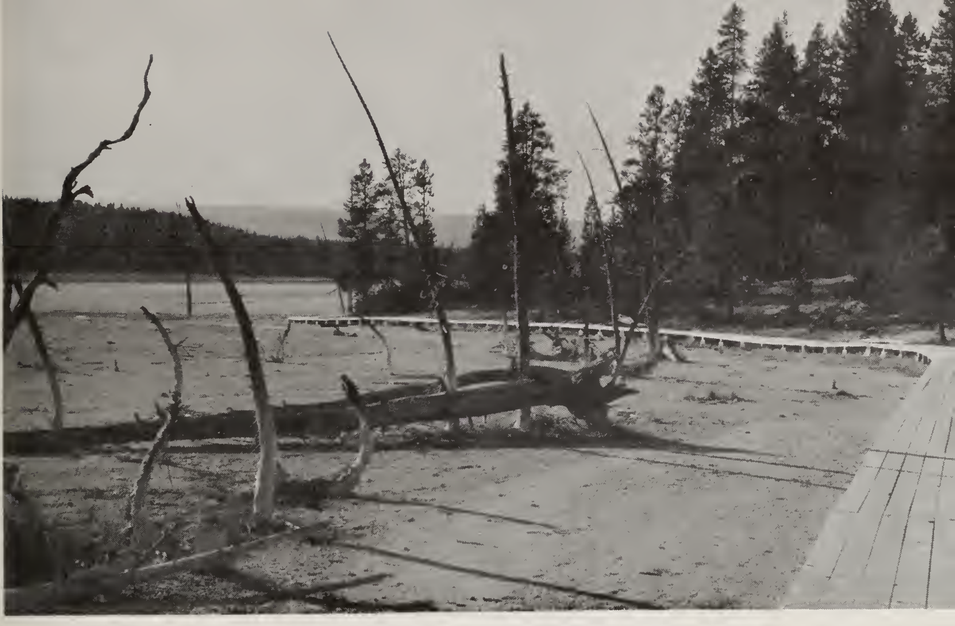
CLEPSYDRA GEYSER

The behavior of all the geysers in this basin was profoundly affected by the Hebgen Earthquake. Clepsydra Geyser before the quake would frequently spurt from the central vent. After the earthquake it went wild and began erupting steadily. Now it stops playing for a few minutes. It may gradually return to pre-earthquake behavior. It is a curious fact that most of the earthquake injured hot springs have seemingly mended. Change, however, is the constant companion of time.

GEYSERITE

This broad whitish mound is being built by the geysers. Geyserite, as the rock is called, is really opal, or simply the common mineral silica containing a little water. Largely an evaporation product of hot spring water, it is more appropriately named silicious sinter (cinder). The process of deposition is a mystery. Upon evaporation of the water, an insoluble residue readily forms on anything including eye glasses. In the laboratory it is difficult to simulate nature and extract silica from hot spring water by any method other than evaporation. The water will stand in sealed jars for years without precipitating silica. Yet it must precipitate from solution in nature. How else could it form under water to line the bowls, tubes and side chambers of hot springs and geysers?

On the way to Old Faithful you see several hot spring basins. Geyserite is forming in these basins, each spring spreading a layer around it that merges with a layer from a neighboring spring. Nine miles of the Firehole valley is "plated" with sinter. The first of the sinter probably appeared when hot springs rejuvenated behind the melting glaciers. The mineral forms at varying rates about each spring. The accumulation of geyserite, however, is balanced against erosion. For most of the year, ice wedges the sinter sheets causing them to spall. Around some springs more geyserite is worn away than is deposited. All factors considered, it must have taken several thousand years to build this sinter mound.



Lodgepole Pine skeletons—drowned by a shift in hot spring run-off waters.

LODGEPOLE PINE

Sinter is not totally silica but an amalgamation of materials carried in hot spring water and of life once existing on it. Various minerals and organic material become fused with the silica. So sinter is not completely sterile and can sustain abstemious large plants such as pioneering Lodgepole Pine. It is a tenuous life. A shift in run-off can flood around the pines and drown them. Such was the fate of the dead trees on the opposite side of the walk. As you explore the geyser basins, you will spot stony remnants of trees, petrified testimonials to a hot spring's fickleness.

Stark lifeless trees with white bases are a common scene in geyser basins. They are victims of Nature's drive to populate every habitable environment no matter how risky the existence might be.

Upon death the drowned tree begins to petrify. Capillary action lifts mineral laden water into the base of the trunk. Old cell spaces fill with water. As the water evaporates, it is continually replaced. Thus a cell becomes gradually filled with silica that is left behind by the evaporating water. The woody cell walls remain, but so impregnated with geyserite is the trunk base that it does not rot. These trees may have been standing for many decades.

CELESTINE POOL

Like most lovely things, hot springs are fragile and ephemeral. Earthquakes can suddenly make or break them. Most of them, though, are destined for gradual degeneration through the centuries. Ironically they seal their own fate. The geyserite that lines their tubes continues to form and it increasingly constricts the passageway. In time a spring will be choked by its own deposits.

The demise of a hot spring is hastened by anything thrown into it. Will you help to preserve these features for others who will follow you here in the future? We hope through this trip you have come to know a bit more about the fascinating world of hot springs.

PLEASE RETURN THE LEAFLET TO THE BOX.

YOU MAY PURCHASE IT BY LEAVING 15¢ IN THE COIN RECEPTACLE

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If you would like to learn more about Yellowstone's geology, the following publications will be of help:

The Story of Old Faithful Geyser, George D. Marler

Studies of Geysers and Hot Springs Along the Firehole River, George D. Marler

Yellowstone's Living Geology, William A. Fischer

These are sold by the Yellowstone Library and Museum Association and may be purchased at visitor centers around the Park. The Yellowstone Library and Museum Association is a non-profit educational society organized to assist the interpretive program of Yellowstone National Park.

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Geology

STUDIES OF GEYSERS AND HOT SPRINGS ALONG THE FIREHOLE RIVER—Marler—50 pp.	.55
THE STORY OF OLD FAITHFUL GEYSER—Marler—42 pp. illus.	.50
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